



AMATEUR RADIO WORKING WITH dB

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Simple Facts & Rules



- ◆ Fact: Any whole number may be calculated by adding or subtracting combinations of 3's, 10's or 0.
- ◆ Rule: NEVER use more than five (5) 3's when performing the combination of 3's & 10's to calculate a whole number.

Using 3's, 10's & 0 (Simple rules)



- ◆ $0 = 0$
- ◆ $1 = 10 - 3 - 3 - 3$
- ◆ $2 = 3 + 3 + 3 + 3 - 10$
- ◆ $3 = 3$
- ◆ $4 = 10 - 3 - 3$
- ◆ $5 = 3 + 3 + 3 + 3 + 3 - 10$

Using 3's, 10's & 0 (Simple rules)



◆ $6 = 3 + 3$

◆ $7 = 10 - 3$

◆ $8 = 10 + 10 - 3 - 3 - 3 - 3$

◆ $9 = 3 + 3 + 3$

◆ $10 = 10$

Etc.

Using 3's, 10's & 0 (Simple rules)



Negative whole numbers

◆ $-1 = 3 + 3 + 3 - 10$

◆ $-2 = 10 - 3 - 3 - 3 - 3$

◆ $-3 = 0 - 3$

◆ $-4 = 3 + 3 - 10$

◆ $-5 = 10 - 3 - 3 - 3 - 3 - 3$

Etc.

More Facts



- ◆ When computing gain you Add and Subtract dB values to find the total gain in dB.
- ◆ Once you know the Total Gain in dB you convert the dB value to its Power Ratio Factor then multiply the input power by the Power Ratio Factor to find the Output Power or ERP (Effective Radiated Power) for an antenna system.

More Facts & Rules



- ◆ $0\text{dB} = \text{Power Ratio Factor of } 1.0$
- ◆ $10\text{dB} = \text{Power Ratio Factor of } 10.0$
- ◆ $-10\text{dB} = \text{Power ratio Factor of } 0.1$
or $\div 10$
- ◆ $3\text{dB} \approx \text{Power Ratio Factor of } 2.0$
- ◆ $-3\text{dB} \approx \text{Power Ratio Factor of } 0.5$
or $\div 2$

(Note: 3dB is only approximately 2.0 x)

Reality



FACT:

- ◆ 3 dB = Power Ratio Factor of 1.995262

Rule of Thumb

- ◆ 3dB \approx Power Ratio Factor of 2.0

Result:

- ◆ Our rule-of-thumb yields an error of 0.24%
- ◆ Following the basic rule of NEVER using more than five 3's would result in a maximum error of 1.19%

(You'll will be shown how to reduce the max error to < 1.00 %)



Converting dB to Power Ratio Factor

Recall:

- ◆ When computing gain you Add and Subtract dB values to find the total gain in dB.
- ◆ Once you know the Total Gain in dB you convert the dB value to its Power Ratio Factor then multiply the input power by the Power Ratio Factor to find the Output Power.

Converting dB to Power Factor



Calculate Power Ratio Factor for 4dB gain:

- ◆ Combine 3's & 10's to form the whole number 4.
 - ◆ $10 - 3 - 3 = 4$
- ◆ Substitute the Power Ratio Factors for each 10 and 3 in the above calculation.
 - ◆ $10 \div 2 \div 2 \approx 2.50$ or
 - ◆ $10 \times 0.5 \times 0.5 \approx 2.50$

Converting dB to Power Factor



Calculate Power Ratio Factor for -8dB gain:

- ◆ Combine 3's & 10's form the whole number -8.
 - ◆ $3 + 3 + 3 + 3 - 10 - 10 = -8$
- ◆ Substitute the Power Ratio Factors for each 10 and 3 in the above calculation.
 - ◆ $2 \times 2 \times 2 \times 2 \div 10 \div 10 \approx 0.16$ or
 - ◆ $2 \times 2 \times 2 \times 2 \times 0.1 \times 0.1 \approx 0.16$

Converting dB to Power Factor



Calculate Power Ratio Factor for -1dB gain:

- ◆ Combine 3's & 10's form the whole number -1.
 - ◆ $3 + 3 + 3 - 10 = -1$
- ◆ Substitute the Power Ratio Factors for each 10 and 3 in the above calculation.
 - ◆ $2 \times 2 \times 2 \div 10 \approx 0.8$ or
 - ◆ $2 \times 2 \times 2 \times 0.1 \approx 0.8$

Converting dB to Power Factor



Calculate Power Ratio Factor for 7dB gain:

- ◆ Combine 3's & 10's form the whole number 7.
 - ◆ $10 - 3 = 7$
- ◆ Substitute the Power Ratio Factors for each 10 and 3 in the above calculation.
 - ◆ $10 \div 2 \approx 5.0$ or
 - ◆ $10 \times 0.5 \approx 5.0$

Tolerance...



Recall:

- ◆ Fact: $3 \text{ dB} = 1.995262 \text{ PRf}$
- ◆ Rule of Thumb: $3\text{dB} \approx 2.0 \text{ PRf}$

Result:

- ◆ Our rule-of-thumb yields an error of 0.24% for 3dB
- ◆ When using five 3's the cumulative error (our maximum error) becomes 1.193%.

(You'll will be shown how to reduce the max error to $< 1.0 \%$)

Advanced Work...

Reducing the Error



- ◆ Any whole number may be calculated by adding or subtracting combinations of 3's, 10's or 0 without using more than five 3's in the combination.
- ◆ Two rule compliant combinations exist for all numbers where the quantity of 3's used = 5.

Advanced Work...

Reducing the Error



- ◆ Five 3's are used in the combination to form whole number 5
 - ◆ $3 + 3 + 3 + 3 + 3 - 10 = 5$ or
 - ◆ $10 + 10 - 3 - 3 - 3 - 3 - 3 = 5$
- ◆ Substitute PRf values for the 3's & 10's
 - ◆ $2 * 2 * 2 * 2 * 2 * 0.1 \approx 3.2$
 - ◆ $10 * 10 * 0.5 * 0.5 * 0.5 * 0.5 * 0.5 \approx 3.125$
- ◆ Since both combinations use five 3's they have the same cumulative error and we can use their average to reduce the error and derive the PRf.
 - ◆ $(3.2 + 3.125) \div 2 = 3.165$ (Rule-of-Thumb)

Advanced Work...

Factoid



- ◆ Fact: $5\text{dB} = 3.16227766 \text{ PRf}$
- ◆ Rule-of-Thumb: $5\text{dB} \approx 3.165 \text{ PRf}$
 - ◆ An Error of 0.007%

Qty of 3's used	Error	Interpolating
1	0.237%	
2	0.475%	
3	0.714%	
4	0.953%	
5	1.193%	0.007%

By Interpolating the value between the two Rule-of-Thumb values we've reduced our maximum error from 1.193% to $< 0.96\%$.